ARIZONA DEPARTMENT
OF
ENVIRONMENTAL QUALITY

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via e-mail

October 8, 2015
FPU16-080

Ms. Catherine Jerrard
AFCEC/CIBW
706 Hangar Road
Rome, NY 13441

RE: WAFB – ADEQ Comments – ADEQ Comments on ST012 SEE Weekly Progress Reports through September 14, 2015

Dear Ms. Jerrard:

Arizona Department of Environmental Quality (ADEQ) Federal Projects Unit (FPU) and ADEQ contractor UXO Pro, Inc. reviewed Steam Enhanced Extraction (SEE) progress report documents and other periodic SEE program monitoring reports. These general and specific are a compilation. General and Specific Comments are provided below.

General Comments

1. ADEQ remains concerned contaminants are not captured. Elevated contaminants of concern concentrations are reported at Steam Enhanced Extraction (SEE) perimeter wells.

2. ADEQ remains concerned that the contaminant plume is not characterized. ADEQ's opinion is the existing monitoring well network is insufficient to delineate migrated contaminants.

3. ADEQ management believes clean up can be accelerated. Management opinion is that remedial clean up activities could be currently performed in perimeter areas to accelerate clean up. Monitoring and remedial action wells can be placed and utilized outside of the SEE direct impact areas.

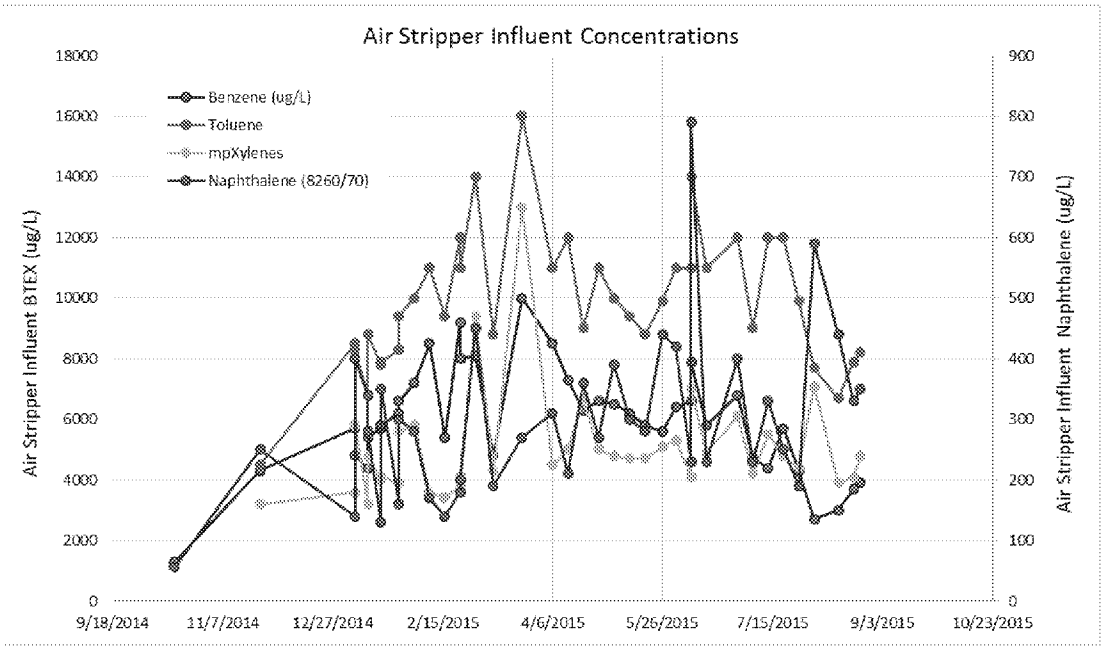
Specific comments are presented on the following pages.

Specific Comments

Comments on Recent Weekly Progress Reports through 14-Sept-15

Section 3. PID Measurements

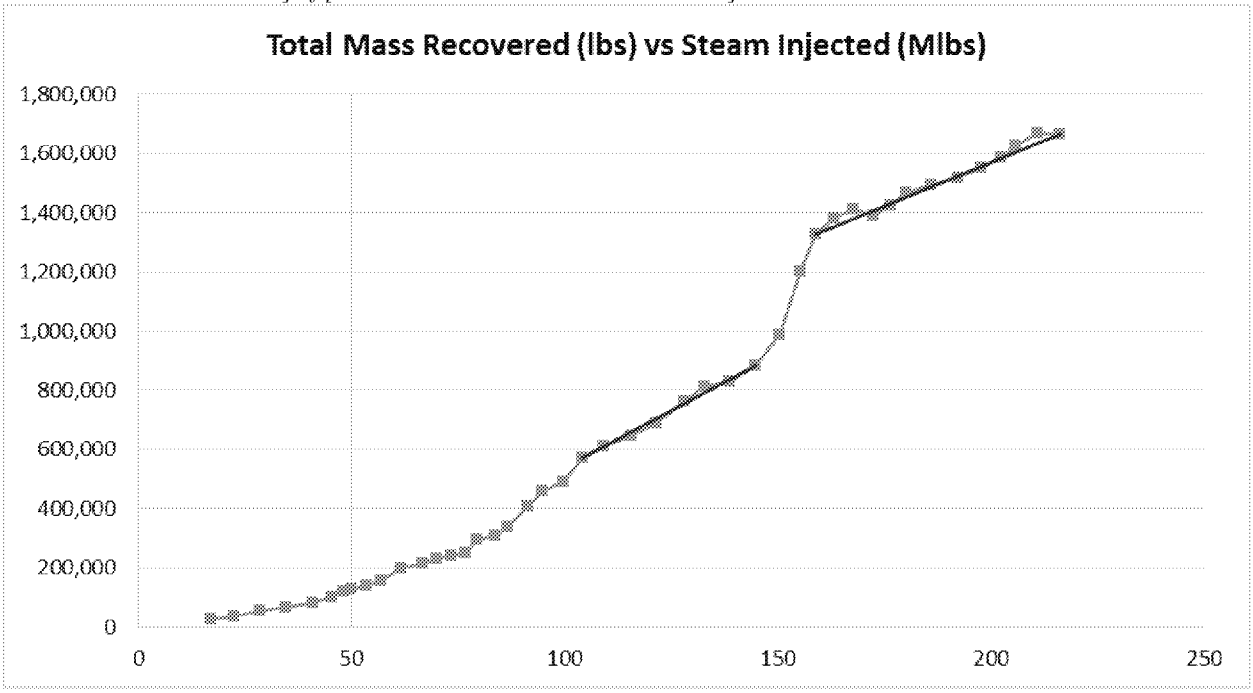
PID concentration trends plotted in Figure 2 are difficult to evaluate when plotted on a logarithmic scale. The anticipated increases in vapor concentration associated with pressure cycling are not apparent in Figure 2. Any increases in the wellfield effluent PID reading associated with pressure cycling are obscured by other data. Laboratory data for water concentrations entering the air stripper are plotted below and do not reveal a correlation with pressure cycling. However, overall recent trends are decreasing for benzene and increasing for naphthalene in the water. Laboratory data for the thermal accelerator inlet is lacking since 8-Jul-15.



Section 4. Mass Removal

The cumulative mass removal plotted in Figure 3 shows an inflection point for a decrease in the rate of mass recovery around June 20th coinciding with the initiation of de-pressurization the LSZ. The inability to assess mass removal from individual treatment intervals (CZ, UWBZ, LSZ) hampers the evaluation of performance.

The mass recovery is plotted below as a function of cumulative steam injected instead of date. Steam breakthrough in a number of wells may coincide with the jump in mass recovered between the cumulative steam injection of 150 to 160 Mlbs. However, the rate of mass recovery, illustrated by the slope of the red line, is similar in value before and after the jump in mass recovery. The data do not indicate a significant decay in recovery rate after breakthrough.



Section 5. Daily Mass Removed

The note to Figure 4 states that accumulated LNAPL is recovered in a batch style process. Therefore, in evaluating the mass removal rate, the data should be smoothed to match more closely actual conditions. In assessing the transition to EBR, the peak value for LNAPL recovery of ~24,000 lbs/day shown in Figure 4 is not appropriate. The peak value for comparison should be an average over several weeks because of the batch process.

Section 8. Vertical and Horizontal Temperature Profiles

TMP-11 indicates steam in the CZ at a depth of 145 ft bgs. This TMP is located approximately 60-65 feet from the TTZ boundary and about 50 feet beyond a steam injection well with no extraction in the vicinity to prevent heat/steam, and therefore NAPL, from migrating outward and beneath Sossaman Road in the CZ.

TMP-6 also indicates steam in the CZ outside the TTZ and beyond the HZ and similarly lacks extraction to prevent adverse NAPL migration.

TMP-13 seal appears to be compromised above a depth of 205 ft bgs. The relatively uniform profile is inconsistent with other locations. If so, only two locations out of six indicate steam in the TTZs of the CZ and the UWBZ: TMP-1 and TMP-12. However, TMP-12 suggests the steam zone in both intervals is narrow in depth (<10 feet). These temperature readings indicate a thorough heating has not been achieved in the CZ or the UWBZ.

In the LSZ, the highest average temperature is on the boundary at TMP-7. Heating has also occurred at TMP-2 located over 100 feet from a steam injection well (LSZ-22) and separated from the injection by two extraction wells (LSZ-14 and LSZ-29). According to Table 4, no steam breakthrough has occurred at LSZ-14 or LSZ-29 yet heated conditions remain at TMP-2. For heating to occur as far as TMP-2, the energy (hot water) had to bypass the extraction wells by convection because heating cannot be explained by thermal

conduction. NAPL could flow adversely away from the TTZ with the hot water and insufficient monitoring exists to make a determination.

Similarly, beyond the southern boundary of the LSZ TTZ, a thick steam zone (~20 feet) exists at TMP-10 even though it is located over 70 feet from a steam injection well (LSZ-25) and is separated from the injection by two extraction wells (LSZ-12 and LSZ-36). According to Table 4, no steam breakthrough has occurred at LSZ-12 and steam has not been detected at LSZ-36 since 15-June-15 yet steam remains at TMP-10 and is increasing in thickness. The existence of a thick steam zone at TMP-10 is not consistent with the concept of hydraulic containment wherein external flow is toward the TTZ and not away. Hence, NAPL may be mobilized to the south and insufficient monitoring exists to make a determination.

Section 15. Cumulative Energy Balance

The energy balance shown in Figure 20 has been modified to include calculated heat losses that are a combination of heat lost below the TTZ, above the TTZ and outside the TTZ. The calculated heat losses are based on the original SEE model. The SEE Work Plan, Appendix D p.19-20, describes the SEE model as:

> *Numerical water and energy balance calculations were conducted as part of the design effort to investigate the importance of groundwater flux, water and steam extraction rates, steam injection well spacing and steam injection rates for the temperatures that can be achieved in situ. The Site consists of multiple zones with different soil properties (porosity, saturation, groundwater flux), and thus so-called "black-box" models are not fully sufficient for estimating the heat progression at a site like this. Therefore, a water and energy balance code has been developed by TerraTherm to simulate the addition, removal, and loss of energy in each layer of the Site separately, with the layers exchanging both fluids (water, steam) and energy along their boundaries. The calculations also estimate heat losses along the top, sides, and bottom of the TTZ and the impact of groundwater flow into the treatment area, such that relatively accurate total energy demands are derived.*
>
> *The model is based on simplified mass and energy balance principles relevant for SEE operation.*

- What is the definition of a heat loss plotted in Figure 20 and how is it calculated mathematically in the SEE model?
- Are observed heat "losses" above 145 ft bgs (the top of the defined CZ) and below 245 ft bgs (bottom of the LSZ) consistent with predictions from the SEE model calculations? Figures 7 and 8 indicate little heating has occurred below the LSZ and limited heating has occurred above the CZ. Is this the expected response? A comparison of Figure 8 over the last few months shows very little change in the temperature profiles at the bottom of LSZ suggesting very small heat migration downward. If vertical heat losses are small, are the majority of heat losses occurring on the outer surfaces of the TTZ?
- No physical boundaries exist along the outside area of the defined TTZ to prevent the flow of steam. Does the SEE model include calculation of phase change and pressure gradients to define flow directions?
- Is a peer-reviewed description of the SEE model available to assess the validity of the model? If not, please provide the governing mathematical equations, boundary conditions, a description of the underlying equations, and a description of the mathematical solution technique so that the validity of the model can be assessed in its application at ST012.

Figure 20 in the 14-Sep-15 progress report illustrates that the energy injected has been either extracted, remains in the TTZ, or has been transported outside the TTZ (i.e., "lost"). The proportion of injected energy in the TTZ is ~35% while the energy "lost" is ~30% and rising. This observation implies energy is moving away from the TTZ. Energy moving outward is not consistent with the concept that net injection and extraction rates are drawing ambient groundwater inward to the TTZ. Energy may be channeling outward in areas of the site while ambient groundwater is drawn inward in other areas. The movement of NAPL with such flow is more likely outward because of higher temperatures and pressure gradients as compared to the ambient groundwater flow.

ADEQ may add or amend comments if evidence to the contrary of our understanding is discovered at the referenced location; submitted; if received information is determined to be inaccurate; if any condition was unknown to ADEQ at the time this document was signed; or if complementary regulatory agencies bring valid and proven concerns to our attention.

Thank you for the opportunity to review this document. Should you have any questions regarding this correspondence, please contact me by phone at (602) 771-4121 or e-mail miller.wayne@azdeq.gov.

Sincerely,

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